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## Optimizing the control of foot-and-mouth disease in Denmark by simulation– introduction

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Foot-and-mouth disease (FMD) is one of the world's most important contagious diseases of livestock. FMD is a viral disease of cloven-hoofed animals. The virus belongs in the picornaviridae family. Several different serotypes have been identified: A, O, C, SAT1, SAT2, SAT3, and ASIA1. Despite differences in their biology all serotypes are highly contagious.

Animals can become infected through inhalation, ingestion and reproduction. The primary mechanism of spread among animals within herds is by direct contact, through inhalation of virus aerosols. Under the right conditions, including high humidity and stable atmospheric conditions, long distance spread of wind-borne FMD virus can occur, in particular from infected pig farms. However, virus is most often spread between herds by movement of inapparently infected animals. Other sources of infection include contaminated vehicles, equipment, people, meat and dairy products.

The disease is characterized by the formation of vesicles and erosions in the mouth, nose, teats and feet. Although FMD is not very lethal in adult animals, it may cause serious production losses and is a major constraint in international trade. Due to the highly contagious nature of the disease an epidemic can take on huge proportions within a short period of time. An example is the FMD epidemic in the UK in 2001. The epidemic lasted for 7 months. More than 2,000 herds were infected during the outbreak and as many as 9,000 herds received compensation payments as a consequence of the epidemic. More than 4 million animals across GB were slaughtered for disease control purposes. The total costs arising from this outbreak have been put at no less than £9 billion (1).

FMD is an OIE listed disease. The control and eradication of FMD within the EU is governed by EU legislation (2). Before 2001, FMD outbreaks in Europe had been controlled rapidly by using a stamping out policy, involving quarantine, movement restrictions and slaughter and disposal of all affected and in-contact livestock on affected herds, followed by cleaning and disinfection. However, the extent and costs of the FMD crisis in the UK, insufficient FMD-control programs in parts of the world and an increased risk of FMD introduction due to international trade with live animals and animal products and human travelling activities has led to a decision within the EU to allow use of inactivated vaccines for emergency vaccination to control FMD (2). Vaccinated animals are protected against disease but are not totally immune and can still become infected and shed virus. The preparedness for effectively dealing with an outbreak of FMD is of course of major concern for countries with intensive livestock production, such as Denmark. The measures to be taken in an outbreak situation are very demanding in terms of human resources, logistics and costs. Veterinary authorities and the livestock industries have an expressed need to get the best available information generated through scientifically based methods for improving the control and eradication of FMD.

Historical data on FMD spread and subsequent control strategies in Denmark are of limited value because of the development in livestock demographics, animal movement practices and legislation since the last outbreak in 1983.

Because of the scarceness of relevant outbreak data, simulation models are valuable tools for predicting the course of outbreaks (3-6) as well as investigating disease control strategies in peacetime (7-8). Use of stochastic simulation models to investigate the effect of control strategies on a simulated outbreak is considered to be a state-of-the-art approach for assessing control strategies. These models can make use of spatial data, including geographical location of herds, number and species of animals on the premises, and animal movements between herds. The Danish cattle and pig industries have undergone significant structural changes in recent years. The number of herds has decreased, while the average herd size has increased, and this development is likely to continue. Simulation models can be used for estimating the effect of increasing this limit on a simulated FMD outbreak in Denmark.

For the above mentioned reasons we decided to explore the modeling potentials of the InterSpread Plus (ISP) model (9), the Davis Animal Disease Spread (DADS) model (10) and the North American Animal Disease Spread Model (NAADSM) (11).

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